REMARKS

By the present amendment and response, claims 93 and 105 have been amended to overcome the Examiner's objections and claims 102-103 and 114-115 have been canceled. Thus, claims 93-101, 104-113, and 116-117 remain in the present application. Reconsideration and allowance of pending claims 93-101, 104-113, and 116-117 in view of the following remarks are requested.

A. Rejections of Claims 93-117 under 35 USC §103(a)

The Examiner has rejected claims 93-117 under 35 USC §103(a) as being obvious with respect to U.S. Patent Number 5,792,706 to Michael, et al. ("Michael") in view of U.S. Patent Number 6,040,248 to Chen, et al. ("Chen") and U.S. Patent Number 6,017,814 to Grill, et al. ("Grill"). For the reasons discussed below, Applicant respectfully submits that the present invention, as defined by amended independent claims 93 and 105, is patentably distinguishable over Michael, Chen, and Grill, singly or in any combination thereof.

The present invention, as defined by amended independent claims 93 and 105, recites, among other things, forming a first air gap, a second air gap, and a support pillar in a first hard mask, and depositing a sealing layer over the first hard mask, a second insulating layer (claim 105), and a first insulating layer, where the support pillar is formed to increase mechanical strength and thermal conductivity of a first interconnect line, and where "said first insulating layer and said sealing layer comprise a low dielectric constant

material." As disclosed in the present application, a first insulating layer formed between interconnect lines and a sealing layer formed over the first insulating layer and a first hard mask can comprise a low dielectric constant material. By utilizing a low dielectric constant material to form the first insulating layer and the sealing layer, the present invention can advantageously achieve an interconnect structure having reduced intra-layer and inter-layer capacitance.

As disclosed in the present application, the present invention can provide a support pillar situated between air gaps formed in a hard mask, where the support pillar and air gaps can have any shape. By appropriately controlling the size and shape of the first and second air gaps formed in the hard mask and the distance between the first and second air gaps, the size and shape of the support pillar formed between the first and second air gaps in the first insulating layer can be advantageously controlled. As a result, the present invention can form a support pillar to advantageously achieve a desired increase in the mechanical strength and thermal conductivity of an interconnect line situated in contact with the support pillar.

In contrast to the present invention as defined by amended independent claims 93 and 105, Michael does not teach, disclose, or suggest forming a first air gap, a second air gap, and a support pillar in a first hard mask, and depositing a sealing layer over the first hard mask, a second insulating layer (claim 105), and a first insulating layer, where the support pillar is formed to increase mechanical strength and thermal conductivity of a first interconnect line, and where "said first insulating layer and said sealing layer comprise a

low dielectric constant material." Michael specifically discloses first dielectric 20 formed over and between adjacent lines 11, where first dielectric 20 is preferably a TEOS based oxide for improved step coverage and conformality. See, for example, column 5, lines 51-61 and Figure 3 of Michael. In Michael, capping dielectric layer 30, which comprises a layer of silicon dioxide formed from a silane source in a low temperature, atmospheric pressure chemical vapor deposition (CVD), is formed on first dielectric 20. See, for example, Michael, column 6, lines 57-61.

In Michael, low temperature, atmospheric or slightly below atmospheric pressure deposition of a silane base oxide is coupled with high aspect ratio trenches 26 to achieve cusping that serves to seal off the upper portion of trenches 26 without filling trenches 26 with dielectric material. However, Michael fails to teach, disclose, or remotely suggest a first insulating layer and a sealing layer that comprise a low dielectric constant material. In fact, as discussed above, Michael specifies a particular dielectric material and method of deposition for each of first dielectric 20 and capping dielectric layer 30 to achieve specific results. Furthermore, Michael fails to teach, disclose, or even remotely suggest the use of low dielectric constant materials for first dielectric 20 and capping dielectric layer 30 to achieve the specific results discussed above.

Also, Michael specifically discloses forming air gap trenches 26 in first dielectric 20, where air gap trenches 26 extend between first interconnect lines 11. See, for example, column 6, lines 33-38 and Figure 6 of Michael. In Michael, trenches 26 are placed indiscriminately with respect to first interconnect lines 11. See, for example, lines

39-41 and Figures 6 and 7 of Michael. However, Michael fails to teach, disclose, or suggest forming a support pillar between air gap trenches 26, where the support pillar is in contact with an interconnect line, and where the support pillar is formed to increase the mechanical strength and thermal conductivity of the interconnect line. Moreover, by placing air gap trenches 26 indiscriminately with respect to first interconnect lines 11, Michael teaches away from intentionally forming a support pillar between adjacent air gap trenches to increase the mechanical strength and thermal conductivity of an interconnect line.

Additionally, Michael fails to teach, disclose, or suggest a sealing layer deposited over a hard mask, a second insulating layer, and a first insulating layer, as specified in amended independent claim 105.

In contrast to the present invention as defined by amended independent claims 93 and 105, Chen does not teach, disclose, or suggest forming a first air gap, a second air gap, and a support pillar in a first hard mask, and depositing a sealing layer over the first hard mask, a second insulating layer (claim 105), and a first insulating layer, where the support pillar is formed to increase mechanical strength and thermal conductivity of a first interconnect line, and where "said first insulating layer and said sealing layer comprise a low dielectric constant material." Chen is directed to a process for plasma etching of contact and via openings in low-k organic polymer dielectric layers. See, for example, the Abstract of Chen. Chen specifically discloses silicon oxide hardmask 26, which is utilized to etch a contact opening in low-k organic ILD layer 24. See, for example,

column 4, lines 4-9 and Figure 2a of Chen. However, Chen fails to teach, disclose, or remotely suggest a depositing a sealing layer over a first insulating layer, first and second air gaps, and a support pillar, where the sealing layer and the first insulating layer comprise a low dielectric constant material. Furthermore, Chen fails to teach, disclose, or suggest forming a support pillar between two air gaps to increase mechanical strength and thermal conductivity of a first interconnect line. Thus, Chen fails to cure the basic deficiencies of Micheal discussed above.

In contrast to the present invention as defined by amended independent claims 93 and 105, Grill does not teach, disclose, or suggest forming a first air gap, a second air gap, and a support pillar in a first hard mask, and depositing a sealing layer over the first hard mask, a second insulating layer (claim 105), and a first insulating layer, where the support pillar is formed to increase mechanical strength and thermal conductivity of a first interconnect line, and where "said first insulating layer and said sealing layer comprise a low dielectric constant material." Grill specifically discloses structured dielectric layer 1 including bottom component 3, dielectric features 4, and top component 6, where dielectric features 4 might be SiO_2 lines. See, for example, column 2, lines 44-52 and Figure 1 of Grill. However, Grill fails to teach, disclose, or suggest depositing a sealing layer over a first insulating layer, first and second air gaps, and a support pillar, where the sealing layer and the first insulating layer comprise a low dielectric constant material. Furthermore, Grill fails to teach, disclose, or suggest forming a support pillar between two air gaps to increase mechanical strength and thermal conductivity of a first

interconnect line. Thus, Grill in combination with Chen fails to cure the basic deficiencies of Michael discussed above.

For all the foregoing reasons, Applicant respectfully submits that the present invention, as defined by amended independent claims 93 and 105, is not suggested, disclosed, or taught by Micheal, Chen, and Grill, singly or in any combination thereof. Thus, amended independent claims 93 and 105 are patentably distinguishable over Micheal, Chen, and Grill and, as such, claims 94-101 and 104 depending from amended independent claim 93 and claims 106-113 and 116-117 depending from amended independent claim 105 are, *a fortiori*, also patentably distinguishable over Micheal, Chen, and Grill for at least the reasons presented above and also for additional limitations contained in each dependent claim.

B. Conclusion

Based on the foregoing reasons, the present invention, as defined by independent claims 93 and 105, and the claims depending therefrom, is patentably distinguishable over the art cited by the Examiner. Thus, claims 93-101, 104-113, and 116-117 remaining in the present application are patentably distinguishable over the art cited by the Examiner. As such, and for all the foregoing reasons, an early Notice of Allowance directed to all claims 93-101, 104-113, and 116-117 remaining in the present application is respectfully requested.

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Respectfully Submitted,
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